63-4-1

REPORT OF ENVIRONMENTAL OPERATION

BOG BUSTERS

UNITED STATES ARMY TRANSPORTATION BOARD
Fort Eustis, Virginia
June 1963

PREFACE

Project TCB-62-183-EO, BOG BUSTERS, was an environmental operation conducted in Alaska during May and June 1962. The primary objective of the project was to determine the capabilities of selected tracked vehicles to traverse muskeg after the spring thaw.

Delayed thawing attributed to unseasonal weather conditions precluded compilation of sufficient data to predict vehicle capabilities for traverse of this type terrain and recommendations have been made that further investigations be conducted with the objective of improving transportation capabilities in organic terrain.

This report is published for the information of recipients and does not necessarily reflect the official opinion of the Department of the Army.

Fort Eustis, Virginia
June 1963

ROBERT B HARRISON
Colonel, TC
President

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I. INTRODUCTION

A requirement exists for the immediate and continued improvement in the capability of Army motor transport vehicles to operate off-road as well as over improved surfaces to attain and maintain parity of movement with the tactical elements of the modern army. The off-road mobility of existing military vehicles is limited in such areas as ground pressure, speed, and fordability.

As one of its major mission responsibilities, the U. S. Army Transportation Board (USATRANSBD) conducts operations leading to improvement of transportation capabilities in difficult environments. In an effort to further the progress being made in the improvement of motor transport capability, especially in off-road operations, USATRANSBD was directed by OCOFT to initiate Project No. TCB-62-183-EO, BOG BUSTERS.

The project was established to determine the capability of certain special purpose vehicles to traverse the organic terrain, commonly known as muskeg, of subarctic regions after the spring thaw and to develop criteria for predicting a vehicle's mobility over such terrain. Five special purpose vehicles were evaluated during this project. They were:

Carrier, Tracked, 5 1/2-Ton, Nodwell RN 110B

Carrier, Tracked, 5 1/2-Ton, Nodwell RN 110D-2

Transporter, Tracked, 12-Ton, Nodwell RN 200

Carrier, Tracked, 1-Ton, Trackmaster Model 105

Tractor, Crawler, Low Ground Pressure, D-8 (Sno-Cat).

The evaluation was conducted in Alaska at Fort Wainwright and in the vicinity of the Tolovana River, approximately 70 miles north of Fort Wainwright, in May and June of 1962.

II. SUMMARY

BOG BUSTERS was an environmental operation conducted by the U. S. Army Transportation Board in Alaska at Fort Wainwright and in the vicinity of the Tolovana River, 70 miles north of Fort Wainwright, from 14 May to 22 June 1962. The primary objective of the project was to determine the capabilities of certain special purpose off-road vehicles to traverse organic terrain, commonly known as muskeg, under operating conditions prevailing in subarctic regions after the spring thaw and to study the relationship of the organic terrain of subarctic regions to vehicular mobility.

A Low Ground Pressure Crawler Tractor, D-8 (modified standard Caterpillar, Model D-8) and four tracked cargo carriers, with payloads ranging from 1 to 12 tons, were evaluated. The carriers consisted of Nodwell RN 110B, 5 1/2-Ton, Tracked Carrier; Nodwell RN 110D-2, 5 1/2-Ton, Tracked Carrier; Nodwell RN 200, 12-Ton, Tracked Transporter; and Trackmaster Model 105, 1-Ton, Tracked Carrier.

The vehicles were operated through organic terrain both in open areas and on hills and ridges; surface water, heavy timber, and numerous hummocks characterized much of the area. The low ground pressure and flotation capability of the vehicles evaluated permitted them to negotiate with little difficulty all the terrain encountered. Weather conditions, however, were not normal for the season. In all test locations, most of the muskeg had thawed only to a depth of 6 to 8 inches (in a few places, 15 inches), whereas normally by the middle of May, the surface layer has thawed to a depth of 12 to 14 inches. The limited thawing was attributed to a late breakup. Operating conditions precluded compilation of enough data to establish criteria that can be used to predict a vehicle's capability to traverse the organic terrain of subarctic regions following the spring thaw.

The D-8 tractor was evaluated not only to determine its capability to traverse thawed muskeg but also its suitability as a prime mover for one or more cargo trailers (Cargo Transporter, Off-Road, Large-Wheel, 10-Ton, 4-Wheel, M1). The limited operational experience which this project permitted indicates that the D-8 tractor is not suitable as a prime mover for the trailers because of the tractor's low maximum speed and the incompatibility of the steering systems of the two vehicles which greatly limits the maneuverability of the unit.

The capability of off-road vehicles to traverse deeply thawed muskeg in subarctic regions during the spring and summer should be further investigated and data compiled to develop criteria for predicting environmental-vehicle-terrain relationship.

III. CONCLUSIONS

A. General.

1. Operating conditions precluded compilation of sufficient data to develop the criteria necessary to predict a vehicle's capability to traverse the organic terrain of subarctic regions after the spring thaw.

2. Although operating conditions prevented the collection of conclusive data, the performance of the vehicles evaluated indicates that they are capable of traversing muskeg after the spring thaw.

B. Specific Vehicles.

1. Carrier, Tracked, 5 1/2-Ton, Nodwell RN 110B.

a. The vehicle would be improved by--

(1) Installing a splash pan over the opening between the bottom of the cab and the frame to prevent short-circuiting of the spark plugs.

(2) Locating the gearshift in a more accessible position.

(3) Ventilating and insulating the cab adequately.

(4) Installing safety belts.

b. An investigation should be made to determine the weight and type of oil suitable for use in the differential.

2. Carrier, Tracked, 5 1/2-Ton, Nodwell RN 110D-2.

a. The vehicle would be improved by--

(1) Installing a foot throttle and rearranging other controls to facilitate operation, particularly in emergency situations, and to reduce driver fatigue.

(2) Relocating the engine to allow the operator greater visibility to the right front.

(3) Mounting the cab and the cargo bed as separate units on the main longitudinal frame to alleviate racking and prevent excessive strain on the cab.

b. An investigation should be made to determine the weight and type of oil suitable for use in the differential.

3. Transporter, Tracked, 12-Ton, Nodwell RN 200.

a. The steering cables are not reliable.

b. The overhead steering carrier support spring should be of sturdier construction.

4. Carrier, Tracked, 1-Ton, Trackmaster Model 105.

a. The vehicle would be improved by--

(1) Lengthening the cargo bed.

(2) Improving access to the components in the front of the engine.

(3) Installing double-sealed and double-shielded thrust and connector clutch activating bearings in the power selector assembly and making the power selector assembly compartment watertight.

b. For operation through thawed muskeg, the vehicle should be equipped with less aggressive tracks and an enclosed cab.

c. An investigation should be made to determine the cause of the engine overheating and the battery overcharging.

5. Tractor, Crawler, Low Ground Pressure, D-8 (Sno-Cat).

a. The vehicle does not appear to be suitable for use as a prime mover for the cargo trailers because of the limited maneuverability of the combined unit. The tractor's lift capacity exceeds that necessary to tow two Off-Road-Trailers loaded to rated capacity, but its steering system is not compatible with that of the trailer. In addition, the tractor's low maximum speed limits its usefulness as a prime mover.

b. The tractor-trailer combination exhibited excellent traction in the area tested.

C. On-Equipment Materiel.

Maintenance and repair of the Nodwell RN 110-series of vehicles would be greatly facilitated by including an efficient lug wrench in the OEM.

IV. RECOMMENDATIONS

A. Vehicular performance over the organic terrain of subarctic regions be further investigated to develop criteria for predicting and improving the capability of motor transport vehicles to traverse such adverse terrain.

B. The University of Alaska be awarded a grant for the purpose of investigating the relationship of the organic terrain of subarctic regions to vehicular mobility.

C. The vehicles evaluated during this project be modified as detailed in sec. III, par. B, and further evaluated in difficult environments, including the organic terrain of subarctic regions after the spring thaw and during the summer.

V. DETAILS OF OPERATION

A. General.

1. Establishment of project. USATRANSBD Project No. TCB-62-183-EO, BOG BUSTERS, was initiated to ascertain the suitability of certain special purpose off-road vehicles to traverse organic terrain, commonly known as muskeg, under operating conditions prevailing in subarctic regions after the spring thaw* and to develop criteria for predicting a vehicle's mobility over such terrain.

Five vehicles were evaluated during the project; each was evaluated in one or more of three test locations. All of the test vehicles were provided by USATRANSBD except the Nodwell RN 110B which was furnished by the U. S. Army, Alaska. They were:

Carrier, Tracked, 5 1/2-Ton, Nodwell RN 110B

Carrier, Tracked, 5 1/2-Ton, Nodwell RN 110D-2

Transporter, Tracked, 12-Ton, Nodwell RN 200

Carrier, Tracked, 1-Ton, Trackmaster Model 105

Tractor, Crawler, Low Ground Pressure, D-8 (Sno-Cat).

2. General procedure. Operations began on 14 May 1962 and terminated 22 June 1962.

Under USATRANSBD Operation Order 2, dated 011300 May 1962, Task Detachment No. 8, composed of an officer, four enlisted men, and a Department of the Army civilian, was formed to conduct the project. Support personnel (two enlisted men), vehicles, and equipment were provided by the U. S. Army Transportation Arctic Test Activity (USATATA), an activity of the U. S. Army Transportation Board, ** located at Fort Wainwright, Alaska. Two other USATATA enlisted men were assigned on a part-time basis for resupply and mechanical assistance. Additional support personnel,

*The spring thaw or breakup in subarctic regions normally occurs in April and May. The muskeg in some sections becomes highly saturated with water, and the ground thaws as much as 12 to 14 inches. The highly saturated and deeply thawed soil creates special off-road transportation problems.

**Effective 1 August 1962, USATATA became an activity of the U. S. Army Arctic Test Board.

three enlisted men, furnished by the U. S. Army Signal Corps Meteorological Team, Fort Wainwright, were detailed as vehicle operators.

On 14 May, the personnel of Task Detachment No. 8 left Fort Eustis, Virginia, for Fort Wainwright. During the first week, detachment personnel coordinated plans with USATATA personnel and briefed and trained vehicle operators, mechanics, and administrative personnel. They also reconnoitered the area between Fox and Livengood on the Elliott Highway to select an area for the main test site (location No. 1). The site chosen was in the vicinity of Mile 57 of the Elliott Highway where a bridge spans the Tolovana River. Near the bridge, a wilderness campsite, under the jurisdiction of the U. S. Department of the Interior, was selected as the site of the living quarters for project personnel. (USATATA obtained permission from Department of the Interior officials to use the camp facilities.) Test and maintenance areas were designated at several points near the campsite.

From 21 to 28 May, the three Nodwells and the Trackmaster were operated at location No. 3, the Red Course of the Automotive Test Course of the Ordnance Arctic Test Activity (OATA), to give the drivers more experience in operating the vehicles in muskeg. During the week, the D-8 tractor was evaluated for 3 days at this site; this was the only test location in which it was evaluated.

The following week, 28 May to 2 June, the three Nodwells and the Trackmaster were evaluated at location No. 2, the Explosive Ordnance Disposal (EOD) area at Fort Wainwright, south of the Richardson Highway. The movement to the Tolovana River area, planned for that week, was postponed because of a washout on the Elliott Highway where it crosses the Chatanika River; the EOD area was used as an alternate test site.

On 4 June, project personnel, test vehicles, and support equipment departed Fort Wainwright for the Tolovana River area. The three Nodwells, loaded on low-bed trucks, and the Trackmaster, loaded on a 2 1/2-ton truck, were transported to Fox, approximately 10 miles from Fort Wainwright, from where they moved under their own power to the Tolovana River test site.

Support equipment moved in the convoy and used in the field was:

Willys FC-170 pickup with maintenance van body, towing a 1/4-ton trailer transporting a 10-kw generator

Willys FC-170 pickup with camper body

Kitchen-sleeper

250-gallon water trailer

Rolling Liquid Transporter (RLT), M1

Rolling Liquid Transporter Trailer, transporting a CONEX box containing repair parts and tools.

The convoy arrived at its destination late in the afternoon, and personnel established the Base Camp. Figure 1 show location of the Base Camp and testing areas on the Tolovana River.

The major part of the vehicle evaluations were conducted from 4 to 19 June. The evaluation of each vehicle was completed with the exception of the Trackmaster Model 105: excessive deadline time prevented completion of its evaluation.

On 19 June, project personnel, support equipment, the Nodwell RN 110B, and the Trackmaster Model 105 departed for Fort Wainwright. Before they left, the Nodwell RN 110D-2, the Nodwell RN 200, and the Rolling Liquid Transporter Trailer were moved to Livengood for participation in another USATRANSBD project, GEOLAS, [1 *] scheduled to begin on 3 July. The Trackmaster was also to have been moved to Livengood but instead was returned to Fort Wainwright for repair. Upon arrival at Fort Wainwright, personnel spent the rest of the week in postoperative inspection and repair of the test vehicles. Operations ended on 22 June.

3. Test sites and weather conditions.

a. Test sites. Evaluations were conducted at three test sites. Location No. 1 was in the Tolovana River area approximately 70 miles north of Fort Wainwright in the vicinity of Mile 57 of the Elliott Highway between Fox and Livengood, Alaska. The other locations were within the confines of Fort Wainwright: location No. 2 was in the Explosive Ordnance Disposal area, and location No. 3, the Red Course of the Automotive Test Course of the Ordnance Arctic Test Activity.

At each location, the organic terrain, commonly known as muskeg, was thawed and highly saturated with water following the spring breakup. Weather conditions were unseasonable. In the test locations, most of the muskeg had thawed only to a depth of 6 to 8 inches (fig. 2). In a few places, the thaw was as much as 15 inches. Normally by the middle of May, the surface layer has thawed to a depth of 12 to 14 inches.

*Superscript numbers refer to similarly numbered entries in the list of references in the annex.

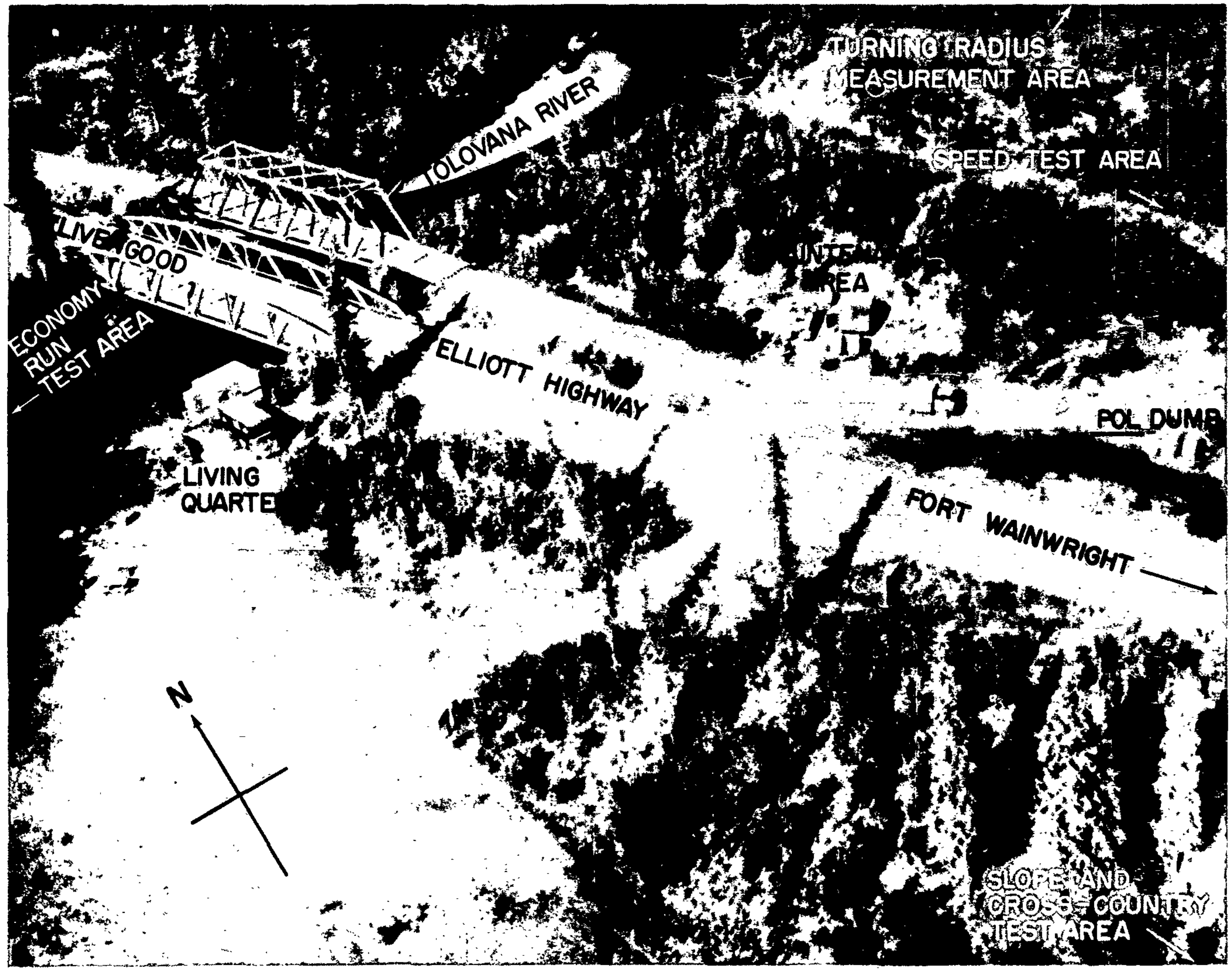

Figure 1. Base Camp and testing areas on Tolovana River.

Figure 2. Hand indicates depth of thaw, 6 inches, in some parts of Tolovana River test area.

The Radforth Classification System [2] was used to classify the vegetal coverage classes found in each of the test locations. A portion of the descriptive system (terms and appropriate symbols) used in the Radforth Classification System to describe muskeg is summarized below.

Coverage type (class)	Properties and examples
A	Woody; 15 ft or over; tree form; spruce, larch
B	Woody; 5 to 15 ft; young or dwarfed tree or bush; spruce, larch, willow, birch
D	Woody; 2 to 5 ft; tall shrub or very dwarfed tree; willow, birch
E	Woody; up to 2 ft; low shrub; blueberry, laurel
F	Nonwoody; up to 2 ft; mats, clumps, or patches, sometimes touching; sedges, grasses
I	Nonwoody; up to 4 inches; often continuous mats, sometimes in hummocks; mosses

(1) Location No. 1. Location No. 1 was near Mile 57 on the Elliott Highway. This area is characterized by relatively flat land lying between hills and ridges (fig 3). The hills are heavily wooded and have grades as steep as 40 percent. Altitudes range from 700 to 1,200 feet. The lowland terrain has some heavily wooded, as well as open, areas. In the open areas, little of the vegetation is more than a foot tall. The Tolovana River is the dominant geographical feature of the area. There are also many smaller streams.

The type of surface vegetation at location No. 1 is primarily BDF; however, class A dominates the banks of the Tolovana River and FI is found in ponds and potholes. Surface vegetation consists of non-woody, 0 to 4 inches, mosses and grasses; woody, 2 to 5 feet, bushes and shrubbery; and, in great abundance, woody, 5 to 15 feet and over. The trees are 6 to 10 inches in diameter. Hummocks, some as high as 18 inches, predominate the open areas. Surface water in ponds was as much as 4 feet deep. The subsurface material consists of coarse as well as fine fibrous peat.

(2) Location No. 2. Location No. 2 was the Explosive Ordnance Disposal area at Fort Wainwright, located south of the Richardson Highway. The terrain is quite level with no rise in elevation in the immediate vicinity. There was a great deal of surface water in the area; some ponds were 4 feet deep.

Figure 3. Typical terrain in Tolovana River area.

The vegetative cover at location No. 2 is characteristic of B and D, woody, 2 to 15 feet tall. The trees are about 3 to 4 inches in diameter. The subsurface material consists of a woody mesh of fibers and particles enclosing amorphous-granular peat.

(3) Location No. 3. The third test site, location No. 3, is the Red Course of OATA's automotive test course. This is the unimproved cross-country, level-terrain course. It is extremely rough and has many 90^{o} turns, both to the left and to the right. There was some surface water on the course; some ponds were as much as 4 feet deep.

On the Red Course, the surface vegetation is predominantly class D, woody, 2 to 5 feet with class A, woody, 15 feet and over, second in predominance. Occasional class E and F coverage, woody and nonwoody, up to 2 feet tall, is also found. Although some hummocks are found on the course, they are not abundant. The subsurface material consisted of a woody mesh of fibers and particles enclosing amorphous-granular peat.

In the fall of 1961, the Red Course was bulldozed. In some areas, it was cut down as much as 12 to 18 inches and as much as 36 inches in some spots. At the time of the evaluation, there had been no regrowth of vegetation. When the area was bulldozed, many of the hummocks were cut off, exposing the subsurface.

b. Weather conditions. The weather during the period of the project was generally clear and warm with little precipitation or wind. At Fort Wainwright, the highest temperature was 86^{o} F and the lowest, 38^{o} F, and the average temperature for the period was 59^{o} F. The total precipitation was 1.98 inches--the greatest portion of which, 1.27 inches, fell on one day, 14 June. The average wind velocity was 7.3 miles per hour. In the Tolovana River area, the average temperature in May was 47^{o} F and in June, 58^{o} F. There was very little precipitation and only light winds during the two months. For the month of May, there was 0.71 inch of precipitation and the prevailing wind was north at 6 miles per hour. For the month of June, there was 0.211 inch of precipitation and the prevailing wind was south at 6.4 miles per hour.

B. Equipment Evaluation.

1. Carrier, Tracked, 5 1/2-Ton, Nodwell RN 110B (figs. 4 and 5).

a. Description. The Nodwell Carrier RN 110B is a highly mobile cargo carrier that can negotiate difficult terrain while carrying a payload of 5 1/2 tons. Although this vehicle was designed primarily as a cargo

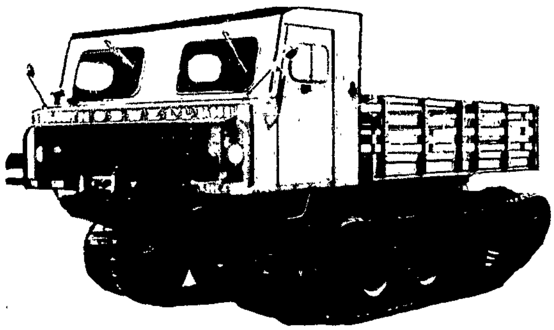

Figure 4. Nodwell carrier, RN 110B, left front, three-quarter view.

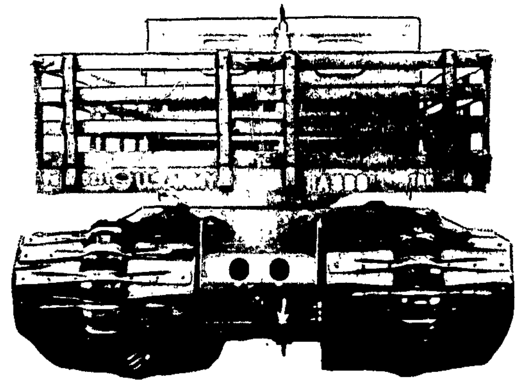

Figure 5. RN 110B, rear view. Arrows indicate towing bracket.

carrier, it also has a limited towing capability. It is steered through levers that hydraulically activate a controlled differential equipped with outer planetary reduction gears. The controlled differential can also be used for braking by activating the steering levers simultaneously. The vehicle has four axles; each axle supports two 12-ply pneumatic tires. Each wheel has an independent crank arm with torsion spring suspension which allows a great deal of independent vertical movement. The tracks are extremely simple: each track consists of two parallel belts of nylon-cotton reinforced rubber and a grouser bar of heat-treated spring steel that extends the width of the track. The tires ride, centered between the belts, in a formed indentation in the grouser bars. Power is transferred from the differential to the track by a rear-drive sprocket of steel overlaid with rubber.

Principal characteristics

Weight, lb	
Net	13,000
Payload	11,000
Gross	24,000
Tires	
Size	7.50x20
Ply	12

Track system	
Type	Ladder, two parallel endless belts connected by grouser bars
Width, in.	40
Grouser	Heat-treated spring steel
Belts	4-ply, 15 inches wide
Vehicle dimensions, overall, in.	
Length	235
Width	107
Height	107
To top of cab	102.5
Cargo space, in.	
Length	144
Width	84
Electrical system	12-volt
Brakes	
Manufacturer	Tru-Stop
Type	Disk
Fuel	
Type	Gasoline
Tank capacity, gal.	42
Performance, land	
Ground pressure, loaded, at 3-inch penetration, psi	2.2
Gradeability, percent	
Forward slope	60
Side slope	30
Turning radius, inside, in.	103
Ground clearance, in.	16
Crusing range, miles (est)	60
Speed, maximum, mph	14.5
Fording depth, in.	60

Engine	
Type	Ford V-8, 292 cu in.
Bhp	142
Transmission	
Manufacturer	Ford, Model T98A
No. of speeds	4
Steering system	Controlled differential, hydraulic, Nodwell No. 15
Winch	
Manufacturer	Ramsey 600
Capacity, lb	12,000

b. Background. The Nodwell RN 110B is one of a family of off-road tracked carriers designed specifically for operation over thawed muskeg, mud, snow, and other adverse terrain. For several years, large oil companies have successfully used Nodwell carriers for off-road transportation of equipment and supplies in exploration and development programs in the Canadian northland.

The RN 110B is a modified version of the RN 110A. The latter vehicle has been evaluated under subarctic, desert, and tropical environmental conditions.[3, 4, 5, 6, 7, 8] During these evaluations, shortcomings and deficiencies were found in certain components of the RN 110A. As a result, some changes and improvements were made and were incorporated in the RN 110B model. They included: use of deeper channels to strengthen the backbone frame, reinforcement of the lateral crossmembers that support the road wheels, installation of heavier and stronger springs and anchors, reinforcement of the pintle and drawbar, use of hardwood planking instead of plywood for cargo decking, and installation of a wider and better insulated cab, a tachometer, and an engine heater.

c. Evaluation. The Nodwell RN 110B was evaluated to determine its capability to traverse muskeg under the operating conditions in subarctic regions prevailing after the spring thaw. The vehicle's gradeability, fordability, and trail-breaking capability were evaluated. Economy, speed, and slope tests were made, and its turning radius was measured. Human engineering and maintenance factors were also determined. During this evaluation, the RN 110B traveled 265 miles, and its engine was operated 56.1 hours. It was tested in locations Nos. 1 and 2 (sec. V, par. A3a).

(1) Overall performance. The Nodwell RN 110B successfully negotiated all of the terrain encountered during this evaluation. In muskeg areas where hummocks dominate, the vehicle, carrying its rated payload, did not break through the surface material on the first pass. The permafrost was reached after five to eight passes over the same area. When fully loaded, the vehicle tore the hummocks somewhat when making sharp turns. The vehicle, when loaded, broke through the surface material on the second pass over the same trail when operated in areas in which there was a great deal of surface water.

In subsequent passes over an area on which the surface material was broken, muskeg accumulated underneath the RN 110B and practically immobilized it. The driver was able to rid the vehicle of excess muskeg by maneuvering back and forth on a firm surface or in water. On one occasion, the vehicle had to be operated for one-fourth mile to get rid of the debris. The towing bracket at the rear of the vehicle caught much of the muskeg: it is not contoured to let the vegetation pass through (fig. 5).

(2) Gradeability. Ravines and steep slopes did not present a problem to the RN 110B. It has excellent traction in rough terrain. Figure 6 shows the vehicle descending a side slope at the Tolovana River test site. The vehicle easily climbed vertical objects up to 1 1/2 feet.

Figure 6. RN 110B descending 30-percent side slope in Tolovana River area.

(3) Fordability. The RN 110B easily crossed streams and ditches 2 to 3 feet wide. It frequently forded water as much as 4 feet deep with no difficulty. On one occasion when the vehicle was operated in 5 feet of water, the engine compartment was submerged, but the vehicle was not immobilized. The engine oil was contaminated; the crankcase had to be drained, flushed, and refilled with clean oil.

(4) Trail-breaking capability. The vehicle showed excellent trail-breaking qualities. It was able to push over trees as much as 6 inches in diameter while negotiating steep slopes or traversing relatively level terrain. Although not designed as a trail-breaker, it can be used successfully in that capacity. To prevent damage to the grille, grille guard, and cab during trail-breaking operations, the RN 110B needs a reinforced cab, a sturdier bumper, and protection for the windshield.

(5) Economy tests. Two 4-hour economy runs were made, one with the vehicle empty and the other with its rated payload. The results were as follows:

	Distance traveled, miles	Fuel consumed, gallons	Miles per gallon	Gallons per mile
Without load	40	21	1.9	5.2
With 5 1/2-ton payload	32	20	1.6	5.0

(6) Speed tests. Four speed runs were made over a measured 200-foot course. The tests were made when the vehicle was carrying no cargo and when carrying its rated payload of 5 1/2 tons. The results were as follows:

	Average speed, mph	Average time to traverse course, sec
Without load	13.9	9.75
With 5 1/2-ton payload	9.5	14.24

(7) Turning radius. The turning radius of the vehicle was measured. The results were as follows:

	Outside turning radius, ft	
	To the left	To the right
Without load	23 1/2	22
With 5 1/2-ton payload	27	26 3/4

(8) Slope tests. Slope tests were made with the RN 110B unloaded and with a 5 1/2-ton load. Without load, it easily traversed forward and side slopes of 58 percent. When loaded, it negotiated 58-percent forward slopes and 40-percent side slopes. Steeper slopes were attempted, but the muskeg was so shallow that the tracks quickly penetrated to the permafrost and could not gain sufficient traction to negotiate them. The results of the tests were:

	Slope, percent	
	Forward	Side
Without load	58	58
With 5 1/2-ton payload	58	40

(9) Maintenance. The Nodwell RN 110B proved almost maintenance free. A daily lubrication of the wheels of the vehicle was necessary. The abundance of surface water and moisture in the muskeg necessitated thorough lubrication to prevent possible rusting. The seals in the wheels are designed to keep water and dirt out rather than grease in. The manufacturer recommends that the wheels be greased sufficiently to force some grease beyond the seal. This will allow any mud and water that gets by the seal to be forced out.

The right front road wheel cracked in four places. These cracks which appeared between four of the boltholes and the axle hole resulted from the nuts of the lugbolts working loose because of vibration. At the time of the failure, the vehicle was operating on the secondary road en route to the Tolovana River area. The wheel was replaced. For the remainder of the evaluation, the nuts of the lugbolts were checked at least twice daily to insure they were adequately tightened. The nuts often worked loose during operation of the vehicle, particularly when the vehicle was operated over rough terrain. The use of the OEM lug wrench was time-consuming: it required one man 10 to 15 minutes to tighten the bolts on one wheel. In addition, the shaft of the OEM lug wrench was too short to allow sufficient clearance between the handle of the lug wrench and the edge of the track, especially when used to tighten the bolts on the front road wheels.

An opening below the engine between the bottom of the cab and the frame, of approximately 3 inches, allowed the tracks to throw wet muskeg on the spark plugs. This caused the spark plugs to short-circuit. Since the vehicle is not equipped with a splash pan, a temporary covering was installed over the opening (fig. 7). This expedient eliminated the problem for the duration of the evaluation.

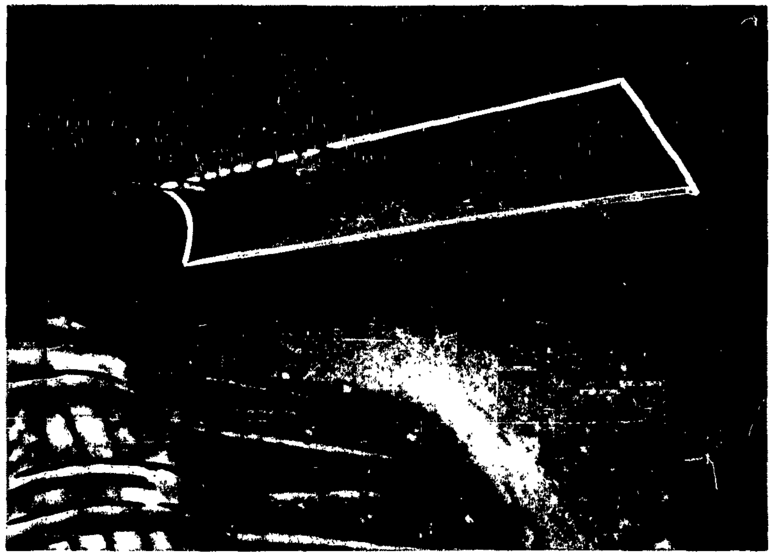

Figure 7. Temporary covering, outlined in white, installed over opening between bottom of cab and frame of RN 110B.

At times, debris accumulated between the radiator and the grille and became matted on the radiator, closing radiator openings. This caused the radiator to overheat. Clearing the debris from the radiator took approximately 5 minutes.

(10) Human engineering factors. The design and comfort of the cab were considered by project personnel. Occupants of the cab have adequate room and are fairly comfortable. They are, however, subjected to excessive jarring when the vehicle traverses hummocks and fallen trees. The cab becomes very warm. The engine, located inside the cab, radiates a great deal of heat although the engine itself is not overheating. The cab doors are left open during operation to allow adequate ventilation. The gearshift lever is located to the right and to the rear of the driver which makes shifting gears awkward. Visibility in all directions is adequate.

2. Carrier, Tracked, 5 1/2-Ton, Nodwell RN 110D-2 (figs. 8 and 9).

a. Description. The RN 110D-2 is a modified version of the RN 110B (sec. V, par. B1a and b). Major differences between the two models are the type of engines and some design features. The RN 110D-2 has a multi-fuel engine, designed to operate on diesel fuel, kerosene, JP fuels, and combat gasoline, whereas the B model has a gasoline engine. The engine compartment of the RN 110D-2 is located to the right of the cab while the engine

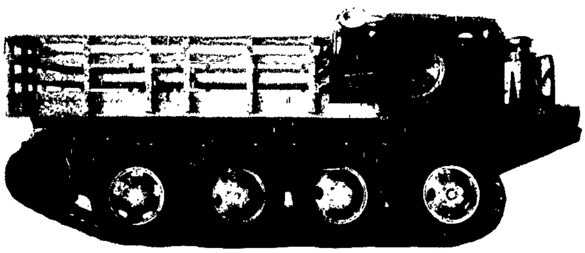

Figure 8. Nodwell carrier, RN 110D-2, right side.

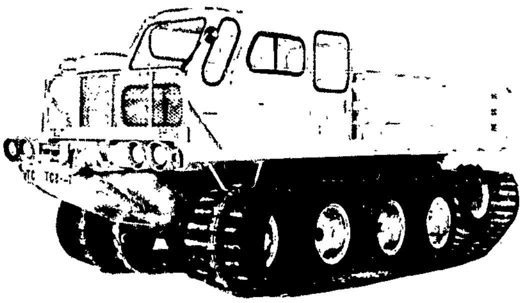

Figure 9. Nodwell carrier, RN 110D-2, left front, three-quarter view.

compartment of the B model is in the usual center front position. The RN 110D-2 has a lower profile, more cargo space, and greater fordability than the RN 110B.

Principal characteristics

Weight, lb	
Net	16,000
Payload	11,000
Gross	27,000
Tires	
Size	7.50x20
Ply rating	12
Track system	
Type	Ladder, two parallel endless belts connected by grouser bars
Width, in.	40
Grouser	Spring steel
Belts	4-ply, 15 inches wide
Vehicle dimensions, overall, in.	
Length	236
Width	107
Height	93

Cargo space, in.	
Length	121 1/2
Width	96
Electrical system	12-volt
Fuel	
Type	Multifuel
Tank capacity, gal.	60
Performance, land	
Ground pressure, loaded, at zero penetration, psi	2.4
Gradeability, percent	
Forward slope	60
Side slope	30
Angle of approach	36°
Angle of departure	20°
Max. width of ditch vehicle can cross, in.	180
Max. height of vertical obstacle vehicle can climb, in.	36
Turning radius, inside, in.	103
Cruising range, miles	100
Ground clearance, in.	16
Speed, mph	15
Fording depth, in.	60
Engine	
Type	GMC, 4-cyl
Hp	105-130 @ 2800 rpm
Transmission	
Type	Allison CT 3340
Speeds	4 forward, 2 reverse
Steering	Nodwell No. 15 controlled differential with outer planetaries

Winch

Type	Ramsey, Model 600
Capacity, lb	12,000

b. Background. USATRANSBD evaluated the RN 110D-2 in Exercise GREAT BEAR [9, 10] early in 1962. After 38 hours of operation, the multifuel engine failed, and no further evaluation of the vehicle was made during the exercise. The engine was replaced with a new one of the same type.

c. Evaluation. The Nodwell RN 110D-2 was evaluated to determine its capability to traverse muskeg following the spring thaw in subarctic regions. The vehicle's overall performance was evaluated. Economy, speed, and slope tests were made, and turning radius was measured. Human engineering and maintenance factors were ascertained by project personnel. During this evaluation, the RN 110D-2 was operated 283 miles. Engine operation totaled 65.8 hours. The vehicle was tested in locations Nos. 1 and 2 (sec. V, par. A3a).

(1) Overall performance. The RN 110D-2 performed well during this evaluation. The vehicle carrying its rated payload, negotiated all the terrain encountered with little difficulty. When operated in an area in which hummocks were abundant, it rode on top of the muskeg, making several passes before it broke through the surface material. When carrying its rated payload of 5 1/2 tons over muskeg highly saturated with surface water, the RN 110D-2 broke through the surface material on the second pass.

(2) Trail-breaking capability. The trail-breaking capabilities of the RN 110D-2 were evaluated on relatively level terrain and on steep slopes. Both when loaded and when unloaded, it was capable of pushing over trees as much as 6 inches in diameter. It can be used successfully to break trail although not designed for that purpose. However, its trail-breaking capability would be improved by the same modifications as suggested for the RN 110B (sec. V, par. B1c(4)).

(3) Economy tests. Six 4-hour economy runs were made with the RN 110D-2 to evaluate its performance with some of the fuels it is designed to use: JP-4, diesel fuel, and combat gasoline. The results were as follows:

	Distance traveled, miles	Fuel consumed, gallons	Miles per gallon	Gallons per hour
JP-4				
Without load	32	8	4	2
With 5 1/2-ton load	28	15	1.87	3.75
Diesel fuel				
Without load	18	8	2.25	2
With 5 1/2-ton load	28	19	1.47	4.75
Combat gasoline				
Without load	30	15	2	5
With 5 1/2-ton load	24	20	1.2	2

(4) Speed tests. Four speed test runs were made with the vehicle over a 200-foot course. These runs were made without load and with a 5 1/2-ton payload. The results were:

	Average speed, mph	Average time to traverse course, sec
Without load	7.43	18.3
With 5 1/2-ton load	7	19.5

The RN 110D-2 had more speed and power when operating on diesel fuel than with either JP-4 or gasoline. It had the least power and speed when burning gasoline.

(5) Turning radius. The outside turning radius of the vehicle was measured. A malfunction in the steering system resulted in excessive turning radii when the vehicle was loaded. The results were:

	Outside radius, feet	
	To the left	To the right
Without load	24	22 1/2
With 5 1/2-ton load	52	83

(6) Slope tests. Slope tests were made with the vehicle when it was both unloaded and loaded (fig. 10). The slopes were traversed without difficulty. The results of the tests were:

	Slope, percent	
	Forward	Side
Without load	58	58
With 5 1/2-ton payload	58	36

Figure 10. Carrier RN 110D-2 climbing an estimated 30-percent slope on OATA Red Course.

(7) Maintenance. Maintenance problems were relatively minor. The overheating of the differential was the main one. The differential overheated during the operation of the vehicle over the secondary road to the Tolovana River area. The overheating caused excessive friction. When the differential overheats, the steering system locks: the steering bands bind or stick to the brakedrum (fig. 11). A heavier weight oil, SAE 90 mineral oil, was substituted for the No. 1065 oil that had been used in previous operations. Use of the heavier weight oil decreased the overheating until it was no longer a serious problem.

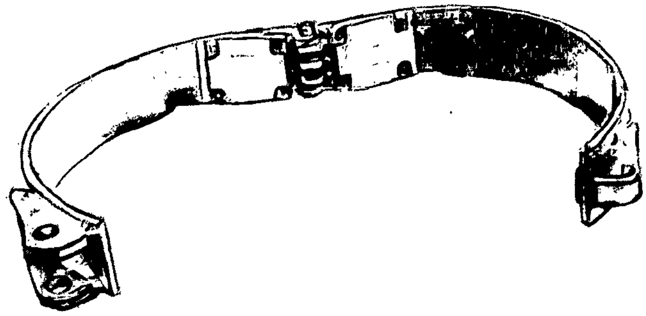

Figure 11. Worn brake lining removed from RN 110D-2 carrier.

The track of the RN 110D-2 was thrown once during this evaluation (fig. 12). It happened when the vehicle was going through a wooded area in which downed trees and stumps were abundant. Generally, it takes three men 2 to 3 hours to reinstall a track. In this instance, it required four men approximately 5 hours to reinstall the track. The rough terrain in which the vehicle was located when the track was thrown prevented

Figure 12. Track of RN 110D-2 thrown as vehicle traversed wooded area.

the track from being laid out properly. The vehicle as well as the track had to be moved several times to find ample space in which to maneuver the vehicle onto the track.

A daily lubrication of the wheels of the RN 110D-2 was necessary. The abundance of surface-water and moisture in the muskeg made it necessary to thoroughly lubricate them to prevent possible rusting. The seals in the wheels are designed to keep water and dirt out rather than grease in. The manufacturer recommends that the wheels be greased sufficiently to force some grease beyond the seal. This will allow any mud and water that gets by the seal to be forced out.

The nuts of the wheel lugbolts were checked each day to insure that they were adequately tightened. These nuts often worked loose because operation over the rough terrain caused considerable vibration. The convex surface in the area between the hub and the lugbolt holes does not permit the nuts of the lugbolts to be properly seated. It is difficult to tighten the nuts securely against this convex surface. The use of the OEM lug wrench was time-consuming (sec. V, par. B1c(9)).

The RN 110D-2 did not use any oil during this evaluation.

The engine of the RN 110D-2 is compact, but its components are not easily accessible. The multifuel engine is more complicated than a gasoline engine and requires a specially trained mechanic.

(8) Human engineering factors. Determinations were made concerning operating controls, visibility afforded the operator, and sturdiness of the cab. The vehicle is operated completely by hand controls. Four of the controls are operated by the right hand: the right steering lateral, throttle, transmission gearshift, and emergency brake. In emergency situations, an inexperienced driver is unable to quickly coordinate all four controls to get the instantaneous response he needs. The need to manipulate so many controls with one hand decreases an inexperienced driver's facility of operation when maneuvering tight turns. A right-handed man can handle the controls with more dexterity than a left-handed man. The operator's visibility to the right front is obstructed by the engine compartment: the engine compartment is higher than the bottom edge of the right window. The cab and the cargo bed are mounted as an integral unit on the main longitudinal frame. This rigid construction subjects the cab to a great deal of stress when the vehicle twists and jolts as it travels over rough terrain. During the project, the cab cracked severely in several places, particularly around the windows.

3. Transporter, Tracked, 12-Ton, Nodwell RN 200 (figs. 13 and 14).

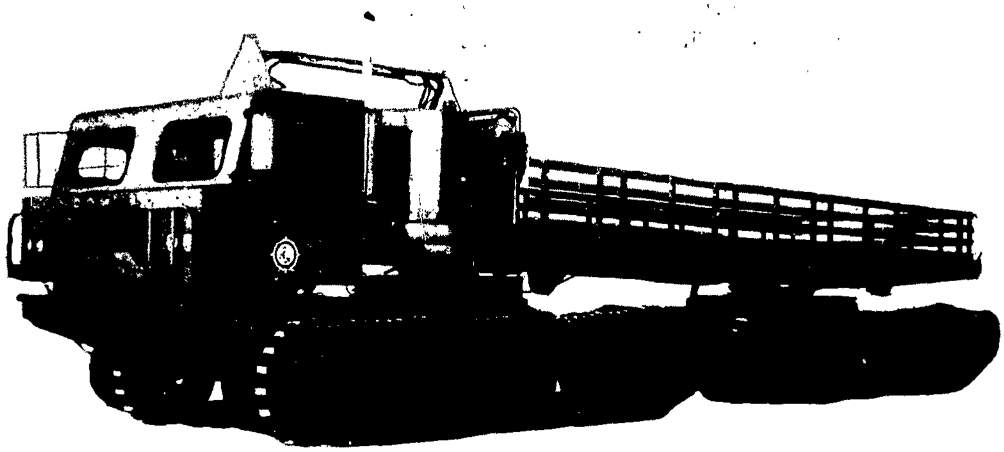

Figure 13. Nodwell carrier RN 200, left front, three-quarter view.

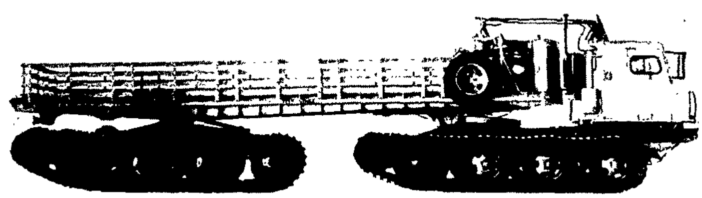

Figure 14. Nodwell carrier RN 200, side view.

a. Description. The Nodwell RN 200 is a four-tracked, eight-axle, 12-ton transporter, designed for off-road operation. Its low ground pressure allows it to traverse thawed muskeg, mud, snow, and other adverse terrain without difficulty. The trail-breaking capability of the vehicle, even through heavily wooded areas, is excellent: it is able to push over trees as much as 10 inches in diameter. The vehicle consists of two units connected by a turning ring articulated joint. Power is provided by two diesel engines, one for each unit, through automatic transmissions and planetary drive rear axles. The front and rear units can each independently assume a transverse or lateral moving angle. The steering system is wheel-controlled through two hydraulic cylinders, mounted under the cargo deck, that actuate two steering cables connected to the turning ring. Control lines for the rear unit pass overhead from the cab to the rear unit by a support carrier. The operator uses tachometers to synchronize the two engines. Each of the vehicle's axles supports two 12-ply pneumatic tires. Each wheel has an independent crank arm with torsion spring suspension, allowing considerable independent vertical movement. The vehicle's endless tracks are of simple construction.

Each track consists of two parallel belts of nylon-cotton reinforced rubber, connected by heat-treated spring steel grouser bars that extend the width of the track. The center portion of the grouser bars is curved to form a tracking surface for the tires. The tires ride in the concave pocket of the grouser bars. Power is transferred from the differential to the tracks by rear drive sprockets of steel overlaid with cast iron.

Principal characteristics

Weight, lb	
Net	47,000
Payload	24,000
Gross	71,000
Tires	
Size	7.50x20
Ply rating	12
Track system	
Type	Two parallel endless belts connected by grouser bars
Width, in.	40
Grouser	Spring steel
Belts	4-ply, 15 inches wide
Vehicle dimensions, overall, in.	
Length	496
Width	123
Height	126
Cargo space, in.	
Length	300
Width	96
Electrical system	12-volt
Fuel	
Type	Diesel
Tank capacity, gal.	168

Performance, land

Ground pressure, loaded, at 6-inch penetration, psi	2.2
Gradeability, percent	
Forward slope	60
Side slope	30
Angle of approach	40°
Angle of departure	90°
Max. height of vertical obstacle vehicle can climb, in.	36
Turning radius, inside, ft	25
Cruising range, miles	125
Ground clearance, in.	16
Speed, mph	15
Fording depth, in.	36

Engines, two

Type	GMC 4-53, 4-cyl
Bhp	130 @ 2800 rpm

Transmission

Type	Allison CT 3340
Speeds	4 forward, 1 reverse

Steering	Hydraulically powered, articulated

Winch

Type	Braden MS9-18B, deck-mounted
Capacity, lb	20,000

b. Background. The RN 200 is one of a family of off-road tracked carriers developed by Robin-Nodwell Manufacturing Ltd. in an effort to solve the mobility problems posed by muskeg. Both industry and the military need a vehicle capable of traversing muskeg under the varying conditions of the different seasons, i.e., a vehicle that can operate through the organic terrain of subarctic regions during both summer and winter. In the winter, frozen muskeg, snow, and ice must be traversed; in the spring and summer, thawed and thawing muskeg, rocks, surface water, and gumbo soils must be negotiated.

Two RN 200's were evaluated by USATRANSBD in Exercise GREAT BEAR, [10, 11] held in Alaska in January and February 1962. During that exercise, the performance of the vehicles was outstanding. They were used successfully in tactical situations as logistical cargo transporters in support of battle groups. They proved highly mobile under subarctic winter environmental conditions and required a minimum of maintenance and operator training.

An RN 200 was also evaluated during Project No. TCB-61-175-OE, WHEELTRACK I, [12] a comparative operational mobility evaluation of wheeled and tracked vehicles, both military and commercial, conducted in April and May 1962 at three locations in Virginia: Fort Story, Fort Eustis (Messick), and Camp A. P. Hill. In all of the tests in which the RN 200 participated, its performance was excellent, but the vehicle was unable to take part in some tests because of maintenance difficulties. Failures of the left steering cable was the major maintenance problem: the cable pulled out of the ferrule on three occasions. A fuel injector was also replaced.

In subarctic operations prior to BOG BUSTERS, numerous steering cable failures occurred on the RN 200. Investigation indicated two main causes: the type of control valve used in the hydraulic system which actuates the steering cables and the improper swaging of the ferrules. Just before evaluating the vehicle in BOG BUSTERS, the hydraulic control valve with a closed center spool was replaced with one supplied by the manufacturer having a free-flow spool. USATATA mechanics brazed the ferrule of a cable that had failed in a previous operation and reinstalled the cable. (In correspondence with USATRANSBD, the manufacturer stated that the ferrules on future steering cables would be properly swaged.)

c. Evaluation. The purpose of this evaluation was to determine the capabilities of the RN 200 to traverse muskeg under operating conditions in subarctic regions following the spring thaw. Characteristics affecting its overall performance were evaluated: gradeability, fordability, and trail-breaking capability. Economy, speed, and slope tests were made, and its turning radius was measured. Human engineering and maintenance factors were also determined. In this project, the RN 200 traveled 211 miles. The front engine was operated 47 hours and the rear engine, 46. The vehicle was operated in locations Nos. 1 and 2 (sec. V, par. A3a) through a variety of thawed muskeg.

(1) Overall performance. The RN 200 negotiated with little difficulty all of the terrain it encountered: it has excellent traction. The vehicle, with its rated payload of 12 tons, rode on top of hummocks, leaving little evidence of the traverse. It did not break through the surface material on its first pass over undisturbed muskeg. The vehicle broke

through the surface material only where surface water was abundant; then vegetation and subsurface material accumulated between the tracks and hampered operation. To remove the debris, the vehicle was maneuvered back and forth over a hard surface or run through a pond. The RN 200 was never immobilized because of accumulated debris.

(2) Gradeability. The vehicle negotiated 58-percent slopes through heavily wooded areas with ease. The RN 200 did not tip or slip when negotiating the forward and side slopes it encountered. Figure 15 shows the RN 200 ascending a 35-percent slope at the Tolovana River test site. It climbed vertical objects 2 feet high with ease.

Figure 15. RN 200 climbing a 35-percent slope at Tolovana River test site.

(3) Fordability. The RN 200 forded ponds 4 feet deep and crossed ditches as much as 1 1/2 feet deep and 5 feet wide without difficulty.

(4) Trail-breaking capability. The vehicle was operated through heavily wooded areas of sloping as well as relatively level terrain. It ascended the slopes without difficulty, easily negotiating grades of as much as 58 percent. While traversing the relatively level terrain, it pushed over trees 10 inches in diameter. It also crossed numerous streams, approximately 4 feet deep, without difficulty. The RN 200 demonstrated excellent trail-breaking capability.

(5) Economy tests. Two 4-hour economy runs were made with the RN 200. The results were:

	Distance traveled, miles	Fuel consumed gallons	Miles per gallon	Gallons per hour
Without load	30	35	0.86	8.75
With 12-ton load	26	35	0.74	8.75

(6) Speed tests. Four speed test runs were made over a 200-foot course on which hummocks were abundant. The results were:

	Average speed, mph	Average time to traverse course, sec
Without load	10.50	13.0
With 12-ton load	7.43	18.3

(7) Turning radius. The outside turning radius of the vehicle was measured. The measurements were as follows:

	Outside radius, feet	
	To the left	To the right
Without load	34	32 1/2
With 12-ton load	44 1/2	48

(8) Slope tests. Slope tests were made with the RN 200. The results were:

	Slope, percent	
	Forward	Side
Without load	58	58
With 12-ton load	58	36

(9) Maintenance. The RN 200 required only minor maintenance and repairs during this evaluation. Daily lubrication of the wheels was necessary to prevent possible rusting: the abundance of surface water and moisture in the muskeg made this requirement mandatory. The seals in the

wheels are designed to keep water and dirt out rather than grease in. The manufacturer recommends that the wheels be greased sufficiently to force some grease beyond the seal. This will allow any mud and water that gets by the seal to be forced out.

Failures of the left steering cable was the main maintenance problem: the cable pulled out of the end ferrule on two occasions. The first time that this occurred the pressure in the hydraulic control exceeded 1,000 pounds; the second time, the pressure was 800 pounds--the normal operating pressure. Apparently, the ferrule was not properly swaged. Before BOG BUSTERS began, USATATA personnel had installed a steering cable one ferrule of which had been brazed following a similar failure in a previous operation. A second steering cable with a brazed ferrule was used as a replacement for the first cable failing in this operation. In both failures occurring on BOG BUSTERS, the ferrule which pulled off was one which had been swaged at the factory, not one that had been brazed (sec. V, par. B3b).

On one occasion, the emergency brake of the vehicle became overheated and started smoking; the grease and oil on the universal joint of the transmission output shaft immediately to the rear of the emergency brake began burning. After the fire was extinguished, it was found that the brake lining was completely disintegrated, the brake springs had lost their temper, and the brakedrum was badly scored: a pebble had lodged between the drum and the band. A new brake band was installed; the brakes were then operational. A few days later, when the vehicle was being driven to the field for testing, the replacement brake band began to overheat and smoke: it was rubbing against the brakedrum. The brakedrum was found to be out-of-round. The brake band was removed, and the vehicle was operated without an emergency brake.

During the evaluation, an hydraulic steering fitting broke when the spring of the overhead carrier support that carries the hydraulic lines to the cab broke. The failure was attributed in part to wear caused by the spring rubbing on the retaining bolts. A new fitting was installed, and the spring was welded and reinstalled (figs. 16, 17, and 18). Later, the spring broke again and was rewelded. The weld was not satisfactory. As a field expedient, the broken coil was discarded and the remainder of the spring was reclamped to its mounting bracket. The vehicle was again operational.

Three tire failures occurred. The walls of two tires were punctured by frozen sticks protruding from the permafrost: the vehicle had penetrated the muskeg to the permafrost. A nail punctured a third tire just as the vehicle arrived at the Tolovana River site.

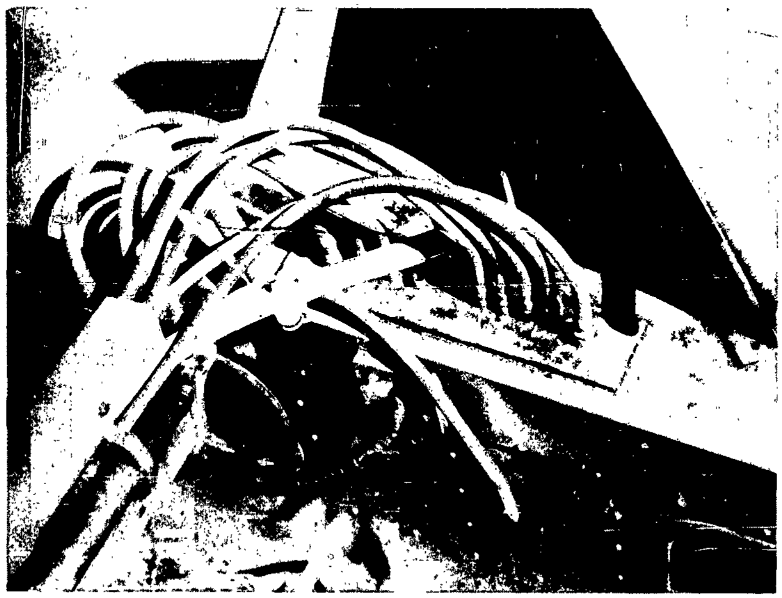

Figure 16. Broken hydraulic control line fitting.

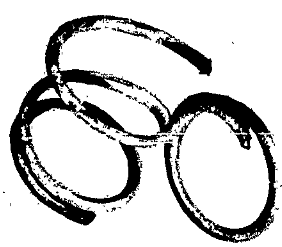

Figure 17.
Broken carrier
support spring.

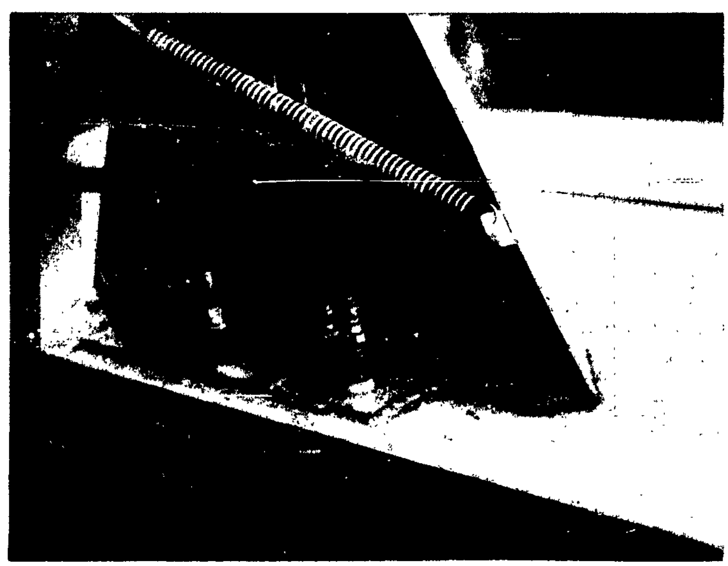

Figure 18. Hydraulic control line:
new fitting installed and
spring repaired.

The front road wheel on the right front track came off. One of the lugbolts had sheared and the nuts of four other lugbolts had worked loose and fallen off because of the vibration created by traversing the rough terrain. It was found the lugbolt holes had worn: the bolts no longer fitted as tightly as they should have.

During this evaluation, the RN 200 used 7 quarts of engine oil and 4 quarts of transmission oil.

Maintenance of the vehicle's front engine is difficult because of the inaccessibility of some components. Access to the lower and rear portions of the engine is particularly difficult. When a leak developed near a fitting in a high pressure oil line, it was necessary to cut an opening in the belly pan to make the repair.

(10) Human engineering factors. Determinations with regard to visibility, comfort, and ease of operation were made by project personnel. The vehicle has a relatively comfortable ride, although there is some vibration when operating over rough terrain. Visibility to the front and side is adequate; to the rear, visibility is obstructed by the rear engine. Steering the vehicle is easily accomplished even though the vehicle lacks fingertip control: the steering system is either fully engaged or completely disengaged. The two hand throttles and two hand gear selectors may prove confusing to an inexperienced operator. At times, he may fail to properly coordinate the two engines.

4. Carrier, Tracked, 1-Ton, Trackmaster Model 105 (figs. 19 and 20).

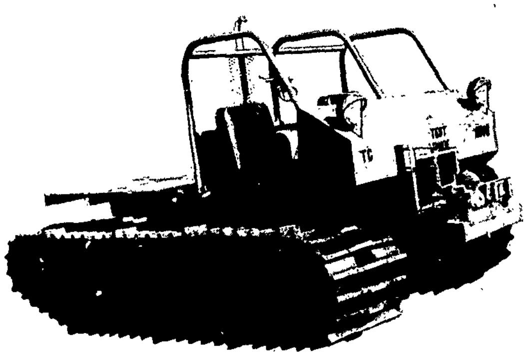

Figure 19. Trackmaster Model 105, right front, three-quarter view.

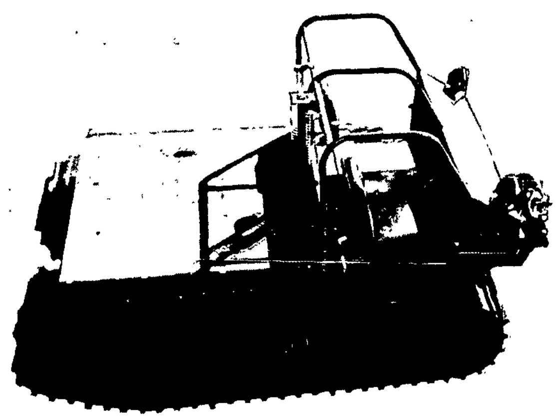

Figure 20. Trackmaster Model 105, right side.

a. Description. The Trackmaster is a tracked carrier with a 1-ton payload capacity. It is one of a family of snow and off-road vehicles used to service ski resorts and to facilitate installation of pipelines, radar, and industrial equipment in remote areas. The Trackmaster is capable of breaking trail through light brush and trees as much as 5 inches in diameter. It has low ground pressure and a low center of gravity.

This carrier has two sprocket-driven, open-center tracks, powered by two drive torque shafts and right-angle drive assemblies. Each track is controlled by a separate steering lever through a power selector assembly which provides power compensation on turns. There are four dry, multiple-disk clutches, two of which are alternately operative with one of two steering levers, permitting a quick change from high to low range, or vice versa, as needed. Both tracks can be powered on turns, using the high speed on one and the low speed on the other. Either speed on each track can be used alternately or both high and low speeds can be used at the same time to give dual drive ratio to the transmission. Each track is driven by a steel drive sprocket that has a 1/2-inch vulcanized rubber coating on the outside of the teeth. The sprockets are splined to the axle. The tracks are made in three sections; each one can be handled readily by one man. Each track assembly includes four road wheels, capable of an 8-inch vertical movement, mounted by an interdependent, spring-controlled suspension. Each of the front road wheels is adjustable longitudinally for controlling track tension. The track grousers consist of formed steel tire guides bolted to duck and rubber track belting with a high center cleat. Every fifth grouser, for its entire length, is the same height as the center of the cleated grousers. This track system is aggressive and affords excellent traction for the vehicle when it is negotiating steep grades. The vehicle is equipped with safety belts.

The Trackmaster Model 105 used in this evaluation was a factory-modified version of the Model 105 used in Exercise GREAT BEAR.[10, 13] It has a flat cargo bed and an open, guarded cab; the model used in Exercise GREAT BEAR was equipped with a tepee over the cargo bed and had a closed cab. The flat cargo bed lends itself to a greater variety of cargo: with a tepee over the cargo area, the cargo has to be of high density to make use of full payload capacity.

Principal characteristics

Weight, lb	
Net	4,410
Payload	2,400
Gross	6,810

Tires

Size	6.40x15
Ply	4

Track system

Type	Ladder, consists of steel cleats with formed steel tire guides bolted to belts
Width, in.	31 1/2
Grouser	Spring steel
Belts	3-ply, 48-ounce duck and rubber

Vehicle dimensions, overall, in.

Length	142
Width	94
Height to top of cab	84

Electrical system	12-volt

Fuel

Type	Gasoline
Tank capacity, gal.	20

Performance, land

Ground pressure, psi	
Empty	0.68
Loaded	1.12
Gradeability, percent	
Forward slope	60
Side slope	50
Turning radius, outside, ft	15
Ground clearance, in.	15
Cruising range, miles	120 to 160
Speed, maximum, mph	35
Fording depth, in.	30

Engine	
Type	Ford 223, 6-cyl
Bhp	130 @ 3600 rpm
Transmission	
Type	Synchromesh
No. of speeds	3 forward, 1 reverse
Steering	Separate steering lever for each track; selective track control
Winch	
Manufacturer	Koenig R-101
Capacity, lb	8,000

b. Background. During a liaison visit to U. S. Army Tank-Automotive Center (ATAC)* in August 1961, USATRANSBD officials learned that the Utah Scientific Research Foundation in association with the Utah State University of Agriculture and Applied Science, Logan, Utah, had designed and built a series of Trackmaster vehicles. (They are now being manufactured by a commercial firm.) Through coordination effected with ATAC, which had ascertained their availability in a survey made of commercial vehicles, USATRANSBD obtained a Trackmaster Model 105. The vehicle, evaluated during Exercise GREAT BEAR in January and February 1962, performed well during its evaluation under subarctic winter conditions. A modified version of the Model 105, considered by the manufacturer potentially more suitable for Transportation Corps use, because of the open cargo bed, was obtained for evaluation in this project.

c. Evaluation. The Trackmaster Model 105 was evaluated to determine its capability to traverse muskeg under subarctic conditions following the spring thaw. The vehicle's overall performance was also evaluated. Economy, speed, and slope tests were made, and its turning radius was measured. Human engineering and maintenance factors were also determined. During this evaluation, the Trackmaster traveled 257 miles and the engine was operated 58.3 hours. Excessive maintenance difficulties and deadline time caused its evaluation to be terminated earlier than scheduled. (Some deadline time was the result of delay incurred in obtaining repair parts). The vehicle was tested in locations Nos. 1 and 2 (sec. V, par. A3a).

*ATAC was formerly Ordnance Tank-Automotive Command (OTAC).

(1) Overall performance. The Trackmaster was operated over a wide variety of muskeg and negotiated with little difficulty practically all of the terrain it encountered. The tendency of the vehicle to throw its tracks when operated over hummocky muskeg was the only operational problem. In making a turn on this type terrain, the vehicle would often "walk out" of the inside track: the tracks were too aggressive. (For optimum operation, the rear end of the tracks should slide several inches when the vehicle is completing a turn. The inside track on a turn had a tendency to dig into the surface of the thawed soil and hold there.) The difficulty was usually apparent before the track was completely thrown. When the track was only partially off, it could be reinstalled in a few minutes by maneuvering the vehicle back and forth. When the track was completely thrown, three men could drive and pry the track on again in 15 to 20 minutes without breaking it (figs. 21 and 22). The track was partially or completely thrown 15 times.

The vehicle's low ground pressure, 0.68 to 1.12 psi, enabled it to ride on top of most of the thawed muskeg with little or no penetration.

(2) Gradeability. Although the Trackmaster's tracks proved too aggressive when making turns in hummocky muskeg, they gave the vehicle excellent traction when ascending steep slopes covered with thawed muskeg. The Trackmaster negotiated both forward and side slopes in excess of 58 percent.

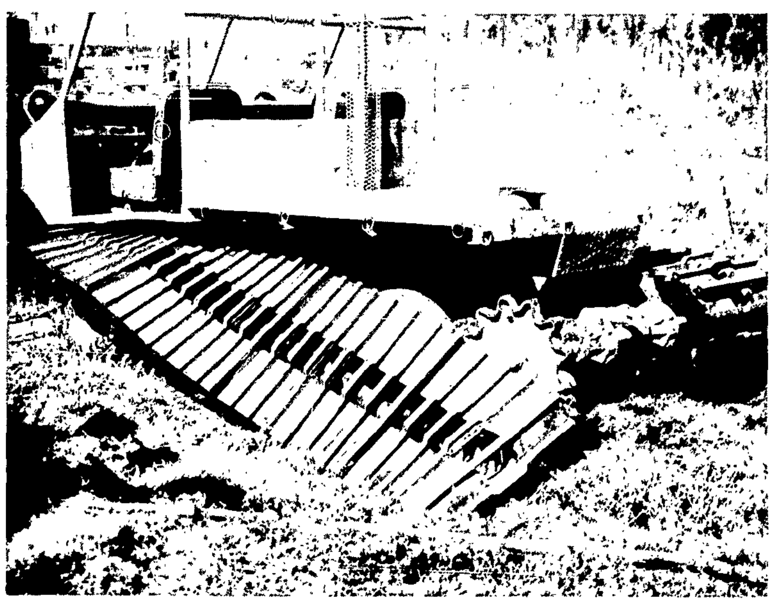

Figure 21. Track thrown when vehicle was traversing relatively level muskeg.

Figure 22. Reinstalling left track of Trackmaster.

(3) Fordability. The Trackmaster forded 30 inches of water without difficulty. On one occasion when operated in water 36 inches deep, the power selector assembly was completely submerged.

(4) Trail-breaking capability. The vehicle was able to break trail without difficulty through light brush and small trees up to 5 inches in diameter, depending on the density of the wooded area.

(5) Economy tests. A 4-hour economy run was made without load. The results were:

Miles traveled	Fuel consumed, gal.	Miles per gallon	Gallons per hour
28	8	3.5	2

(6) Speed tests. Speed tests were made: four runs over a 200-foot course with the vehicle empty and four runs over a 150-foot course with the vehicle loaded. The results were:

	Average speed, mph	Average time to traverse course, sec
Without load, 200-foot course	15.5	8.8
With 1-ton payload, 150-foot course	15.4	6.7

(7) Turning radius. Determination of the vehicle's turning radius was not completed because of a defective left steering clutch on the vehicle. Measurements determined were:

	Turning radius, ft	
	To the left	To the right
Without load	22 1/2	22
With 1-ton load	27 1/2	Not measured

(8) Slope tests. Slope tests were made with the Trackmaster both while unloaded and with its rated payload. (A punctured tire and subsequent throwing of a track prevented completion of the tests.) The results were:

	Slope, percent	
	Forward	Side
Without load	58+	58+
With 1-ton load	58+	Not measured

(9) Maintenance. Some components of the Trackmaster required a great deal of maintenance and repair work, but the engine needed only minimum maintenance. The steering clutches, particularly the left one, continually overheated and smoked. The overheating was partially attributed to the burning of muskeg debris caught in the clutch disks. The steering clutches were adjusted several times; once they were disassembled and cleaned, but this did not improve their operation. During this evaluation, the driver engaged the clutches fully at all times and allowed no slippage of the clutches. The right front wheel, knocked out of alignment during a previous operation, caused the vehicle to pull to the right. To counteract this tendency, the operator had to engage the left clutch excessively. In addition, the steel clutch disks of all four steering clutches had rusted some because of intermittent operation of the vehicle in water over a long period of time. Figure 23 shows worn steel and asbestos clutch disks removed from the Trackmaster.

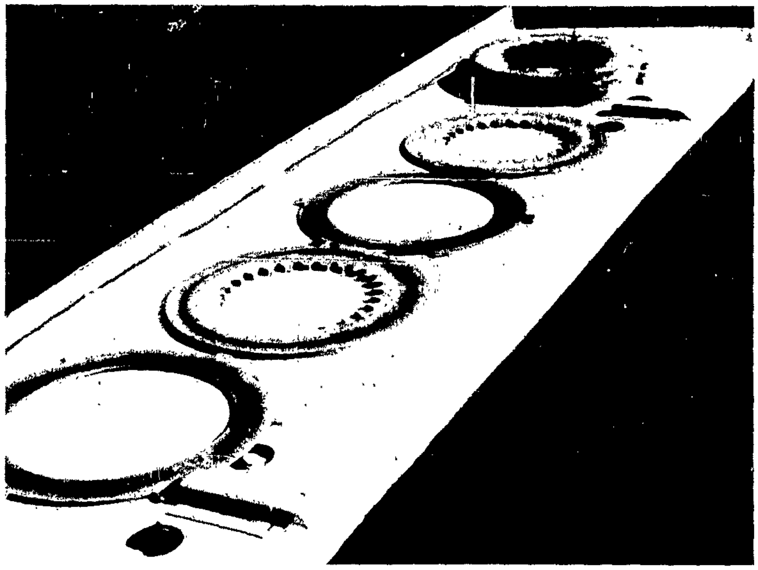

Figure 23. Worn steel and asbestos clutch disks removed from Trackmaster's power selector assembly.

The connector clutch activating bearings, the throw-out bearings, and the thrust bearings in the power selector assembly had to be replaced because of wear from deposits of silt from water seepage: neither the bearings nor the power selector assembly are sealed. On one occasion, when the vehicle exceeded its maximum allowable fording depth of 30 inches, the power selector assembly was completely submerged.

The engine itself required little maintenance. The timing was reset once during the evaluation. Accessibility to many of the major engine components is limited because of the location of the engine and the construction of the vehicle. The winch, radiator, and fan have to be removed to gain access to the front of the engine (fig. 24).

One constant problem was the overheating of the engine. The cause was not determined during the project although the vehicle was deadlined 24 hours on one occasion while mechanics attempted to determine the reason for this trouble. Ambient temperature was never high enough to cause the engine to overheat as it did. On one occasion, the alternator-water pump drive belt broke and had to be replaced.

Another problem was the constant overcharging of the battery. While the vehicle was deadlined to determine the reason for the

Figure 24. Radiator and fan removed to allow access to front of engine.

engine's overheating, personnel tried to find the reason for the battery's overcharging, but they were not successful. (In July 1962 during a post-operative inspection, USATATA personnel found that the voltage regulator was defective.)

On one occasion the right track was thrown because the tire on the front road wheel had been punctured by a stick. To move the vehicle back to the Base Camp, the tire on the second wheel was used as a replacement and its axle arm chained to the frame to keep it off the track. At the Base Camp, the tire was patched. The tire and track were then reinstalled.

(10) <u>Human engineering factors</u>. When the vehicle is operated over rough terrain, the passengers are subjected to excessive vibration; however, the safety belts helped.

The open cab on the vehicle does not protect the driver and passenger from precipitation, falling objects, and overhanging tree, limbs and brush along the trail. The short cargo bed allows mud and debris to be thrown on the cargo and into the open cab by the tracks (fig. 25).

Figure 25. Short cargo bed allows mud and debris to be thrown on cargo and into cab by tracks.

5. Tractor, Crawler, Low Ground Pressure, D-8 (Sno-Cat) (figs. 26 and 27).

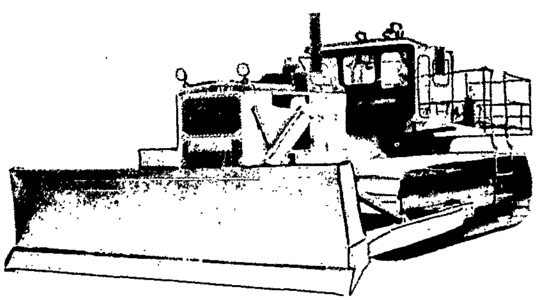

Figure 26. D-8 tractor, left front, three-quarter view.

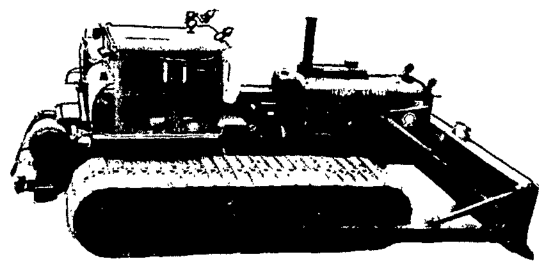

Figure 27. D-8 tractor, right side.

a. Description. This low ground pressure tractor is a modified version of the standard Caterpillar tractor, Model D-8. The vehicle is longer and wider than the standard model; its tracks are also wider. It has a high speed transmission and greater horsepower, but a lower maximum speed. The vehicle is equipped with a 16-foot bulldozer blade and a 49,000-pound capacity, rear-mounted winch.

Principal characteristics

Weight, lb	
Net	72,000
Fuel and driver	4,720
Gross	76,720
Track system	
Type	Steel
Length, in.	208
Width, in.	54
Vehicle dimensions, overall, in.	
Length	288
Width	160
Height to top of cab	126
Electrical system	24-volt
Fuel	
Type	Diesel
Tank capacity, gal.	650
Performance, land	
Ground pressure, psi	4.1
Gradeability, percent	
Forward slope	60
Side slope	30
Angle of approach	35°
Angle of departure	90°
Max. width of ditch vehicle can cross, in.	96
Max. height of vertical obstacle vehicle can climb, in. (est)	144
Turning radius, ft	24
Cruising range, miles	200
Ground clearance, in.	13
Speed, mph	5.2
Fording depth, in.	32

Engine	
Type	Caterpillar Model D-342
Hp	205 @ 1800 rpm
Steering	Hydraulically activated clutches
Winch	
Type	Hyster, rear-mounted
Capacity, lb	49,000

b. Background. The D-8 tractor was developed to fill a requirement of the Corps of Engineers for a prime mover for cargo sled trains on the Greenland Icecap. These tractors have been employed for several years in both arctic and antarctic regions to tow cargo sled trains having a lift capacity of 50 tons.

c. Evaluation. The D-8 tractor was evaluated to determine its capability to traverse muskeg following the spring thaw and its suitability as a prime mover for one or more cargo trailers (Cargo Transporter, Off-Road, Large-Wheel, 10-Ton, 4-Wheel, M1). The fuel consumption rate and rate of speed were determined, and slope tests were made. Human engineering and maintenance factors were also determined. All evaluations of the D-8 were conducted at location No. 3 (sec. V, par. A3a). The vehicle was not taken to the other test sites because the Division of Highways of the Department of Public Works of Alaska does not permit tracked vehicles to operate on hard-surfaced roads. In addition, the one-way bridges between Fort Wainwright and location No. 1 in the Tolovana River area were too narrow for its passage and not all of the bridges could be bypassed because of the high water level following the thaw.* During this evaluation, the vehicle traveled a total of 27 miles and was operated 9 engine hours.

*The Steese Highway from Fort Wainwright to Fox is hard-surfaced. The one-way bridges on the highways between Fort Wainwright and the Tolovana River area are only 12 feet wide and too narrow for the 14-foot D-8 tractor to cross without the removal of the track pads and 16-foot bulldozer blade. Removal of these components to make the bridge crossings was considered too time-consuming. It would have been impossible for the vehicle to bypass the bridge across the Chatanika River because of the high water level. Possibly the vehicle could have bypassed the bridges across the Tatalina and Tolovana Rivers.

The trailers which the D-8 towed during its evaluation are also known as Thompson Trailers. This trailer is a 10-ton, four-wheeled, nonreversible cargo trailer, equipped with 120x48-68R low pressure tires. Its overall dimensions are 39 feet 6 inches by 13 feet 4 inches. The trailer's turning radius is 50 feet. Its 13- by 12-foot cargo deck has a ground clearance of 3 feet. Developed for the Transportation Corps as a replacement for the 10-ton cargo sled, the 10-ton trailer has been tested in the arctic and subarctic and has been type classified standard A. [4, 14, 15]

(1) Overall performance. The D-8 towing both empty and loaded Off-Road Trailers was able to traverse all of the terrain it encountered. It was first tested towing one empty trailer over disturbed muskeg. The surface of the course was relatively firm during the first pass. The vehicle, operated in third gear at 1300 rpm, encountered no difficulty negotiating the course although surface water as much as 4 feet deep was encountered. Track penetration on the first pass over the muskeg was 1 to 2 inches. The penetration, greater with each succeeding pass, reached a depth of 6 inches on the last pass. In succeeding trips over the course, the ground became extremely muddy (fig. 28), but the vehicle did not become immobilized. In the second test, the D-8 towed two trailers: one was empty and the other was loaded with approximately 24,000 pounds. The vehicle, operated in third gear at 1300 rpm, again negotiated the course without difficulty. The low

Figure 28. Muddy course traversed by D-8 tractor without difficulty.

ground pressure of the tractor prevented it from penetrating the surface material more than 6 inches. The wheels of the 10-ton trailers penetrated the surface material to a depth of 18 inches.

The steering systems of the tractor and the trailer are not compatible. The trailer does not track satisfactorily with the tractor. On a turn of only a few degrees, the front wheels of the trailer rub against the trailer frame. The incompatibility of the two steering systems severely limits the unit's maneuverability (fig. 29). The low maximum speed of the D-8 tractor further reduces its usefulness as a prime mover for the Off-Road Trailer.

Figure 29. D-8 tractor towing one Off-Road Trailer failed to negotiate this turn.

(2) Fuel consumption rate. The fuel consumption rate of the D-8 during this evaluation was 2.4 gallons per mile and 7.2 gallons per hour. It consumed 65 gallons of fuel.

(3) Rate of speed. The D-8 has a low rated maximum speed: 4 to 5 miles per hour. The average speed attained was about 3 miles per hour.

(4) Slope tests. The D-8 negotiated without difficulty the slopes on which it was tested. The tests were made on hard-packed dirt and gravel while it was towing one empty trailer. The vehicle was able to negotiate a 40-percent forward slope and a 25-percent side slope.

(5) Maintenance. The D-8 presented no maintenance problems. The only daily maintenance required was checking the oil level and greasing the vehicle. The tracks were cleaned daily to remove debris.

(6) Human engineering factors. Project personnel made the following determinations concerning the cab of the D-8 tractor: the cab is comfortable and has ample space for the operator; visibility in all directions is good; engine and road noises are not annoying.

ANNEX

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53 pp. 29 illus. Unclassified Report

This project was conducted at and in the vicinity of Fort Wainwright, Alaska, May and June 1962, to determine the capabilities of five tracked vehicles (Nodwell carriers RN 110B and RN 110D-2, a Nodwell transporter RN 200, a Trackmaster Model 105, and a LGP D-8 crawler tractor) to traverse the organic terrain (muskeg) of subarctic regions after the spring thaw and to study the relationship of muskeg to vehicular mobility. The thaw was unseasonably late in 1962; consequently, operating conditions precluded making conclusive determinations and compiling sufficient data to develop criteria necessary to predict a vehicle's

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